National Aeronautics and Space Administration

Advanced Chemical Propulsion

In-Space Propulsion Technology Project

NASAfacts

The In-Space Propulsion Technology (ISPT) Office is investing in propulsion technologies to meet future science missions' needs. The objective of the ISPT project is to provide increased science payload capability while decreasing trip times, cost and risk through advanced propulsion technology.

Chemical propulsion is a mature propulsion technology for in-space propulsion. Because of its maturity, the investments in chemical propulsion systems are incremental with a goal of rapid and low-risk technology infusion. These investments are on incremental improvements and subsystem technologies.

Advanced Materials Bipropellant Rocket (AMBR) Engine

Propulsively demanding science mission require the use of a bipropellant propulsion system. For bi-propellant space chemical engines, the maximum theoretical performance of the propellants nitrogen tetroxide and hydrazine (NTO and N_4H_4 respectively) were never reached partially due to the temperature limitation of the rocket chamber material and engine design. The ISPT project initiated the AMBR engine development to fully utilize the material properties of today's state-of-the-art (SOA) bipropellant engines.

To achieve the higher performance goals, the SOA Aerojet HiPAT™ engine was leveraged with advanced manufacturing techniques, injector design, and chamber characteristics to operate the engine at more than 4,000 degree F. The higher temperatures allow the engine to operate with an increased efficiency without changing the engines physical envelope.

The AMBR engine development concluded in 2009. The AMBR engine achieved Technology Readiness Level 6 (TRL 6) after demonstrating increased specific impulse and passing qualification level environmental testing. The AMBR engine enables increased payload capabilities in propulsively challenging missions including those of NASA's Discovery, New Frontier, and Flagship classes.

Pressurization and Mixture Ratio Control

The ISPT project also invested in demonstrating the technologies and viability of active mixture ratio control. Pressure-fed bipropellant systems operate with separate oxidizer and fuel systems. The engine is designed to operate at a specific oxidizer to fuel O/F ratio. Small variations in thruster operation cause uncertainties in the O/F ratio that could cause depletion of either the fuel or oxidizer before all propellant is consumed. Due to

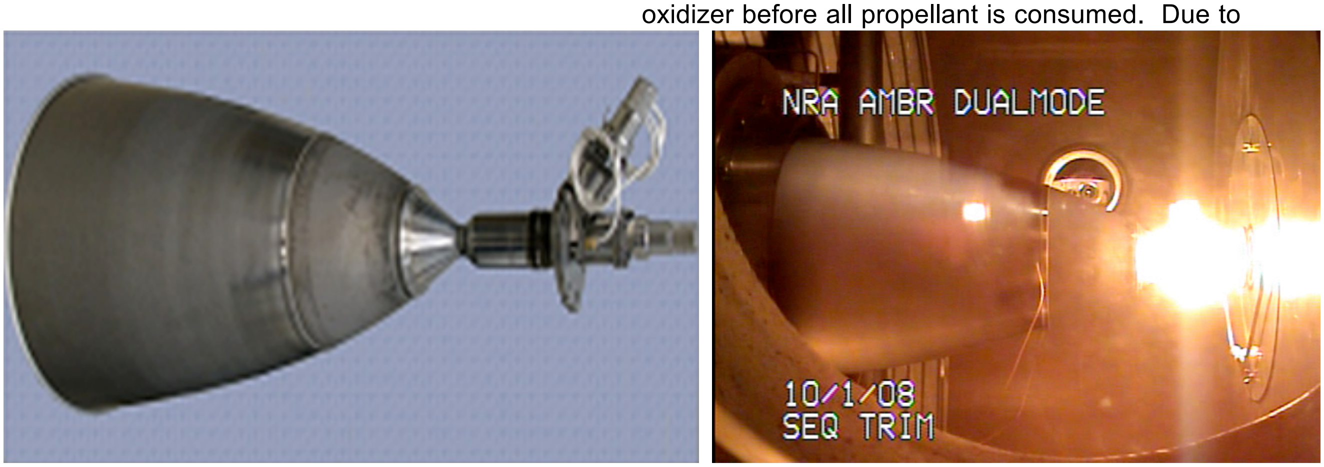

Figure 1. The Advanced Material Bipropellant Rocket (AMBR) engine.

this uncertainty, spacecraft are launched with additional propellant reserves. If the amount of propellant reserve were reduced by a half, the mass savings could be significant – as much as a 10 percent reduction in propulsion hardware mass, or a 15 to 50 percent gain in scientific payload depending on the mission.

Initial project activities included assessing the viability of active propellant mixture ratio control and to confirm that this technology can be developed for a reasonable investment. Component level technologies and system operations were developed and demonstrated. These include the advanced flow meters and new tank liquid mass gauging techniques. The former can potentially minimize the error in propellant flow measurement down to 0.15 percent, and the latter can minimize the volume measurement down to less than 0.5 percent. Both are significant improvements over state-of-the-art.

Propellant pressurization feed system control algorithms were studied using advanced statistical methods to assess performance and impact on reduction of in-flight propellant reserves. Finally, balance flow meters have been demonstrated with hydrazine and nitrogen tetroxide during bipropellant hot-fire testing.

Reliable Lightweight Tanks Components

ISPT continued investments in light-weight composite overwrap pressure vessels (COPVs) The developments in this area were to advance designs, material, and manufacturing technologies for lighter-weight in-space propulsion system tanks. A composite over-wrapped tank provides added strength to the inner, thin walled metallic tank that stores spacecraft propellant and pressurant for a propulsion system.

Typically, propellant tanks are the largest component of in-space chemical propulsion systems and add significant mass to the spacecraft. Lightweight tanks could reduce tank mass by 50 percent while maintaining the same strength and corrosion resistance.

Figure 2. Light-weight composite overwrapped tank

Tasks under light-weight tank technology included improving welding of the liner and components, bonding between the composite overwrap and the liner, and inspection criteria and techniques.

More about the Advanced Chemical Propulsion Program

Development of advanced chemical propulsion for in-space applications focused on near-term products that are built on the proven, state-of-the-art chemical propulsion systems and components. The ISPT Project aims to optimize current technology to improve propulsion systems performance, yielding more capable, cost-efficient science missions. All investments in advanced chemical propulsion concluded in 2009. Documentation and references of all previous investments can be found at the ISPT project website.

For more information about NASA's In-Space Propulsion program and advanced chemical propulsion, visit:

http://spaceflightsystems.grc.nasa.gov/SSPO/ISPTProg/

The In-Space Propulsion Technology project supports the planetary science division of NASA's Science Mission Directorate and is managed out of the Glenn Research Center.

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